AIR FORCE INSTITUTE OF TECHNOLOGY
GRADUATE SCHOOL OF ENGINEERING & MANAGEMENT
RESEARCH NEWS

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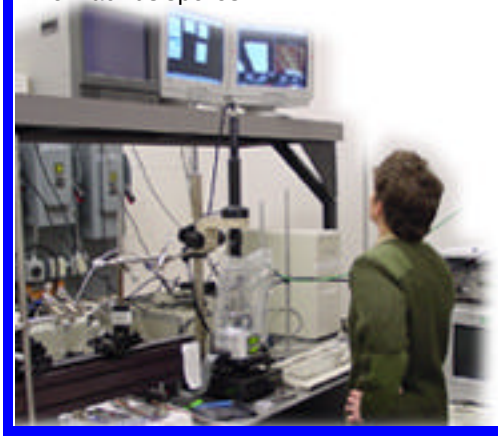
2002 Commandant's Award Winner

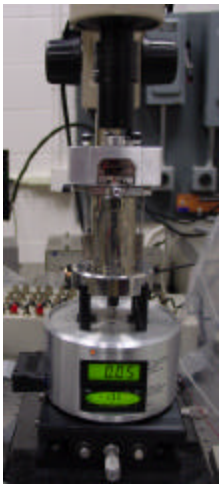
Research On Rapid Identification of Anthrax

Rapid and accurate identification of biological warfare agents remains a scientific and technical problem that has yet to be adequately solved. For *Bacillus anthracis*, the causative agent of anthrax, it is difficult to differentiate the pathogenic bacterium from its many close relatives. It is more important now, than ever, to seek novel and effective means to rapidly and accurately identify this deadly pathogen.

Recent thesis research work conducted by an AFIT student, Captain Ruth A. Zolock, USMC, entitled "Characterization of the Surface Morphology of *Bacillus* Spores By Atomic Force Microscopy," explored the development of rapid means of identification of anthrax spores by characterizing their surface properties using atomic force microscopy. The research expanded the fundamental knowledge of bacterial spores by characterizing the surface properties of *Bacillus* spores.

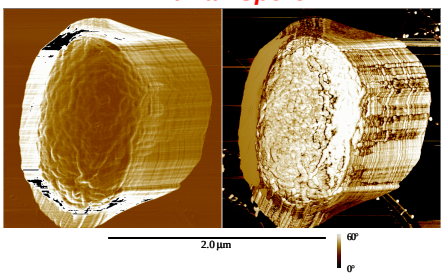


Bacillus spores surface morphology was resolved by atomic force microscopy to determine if characteristic surface features could be used to distinguish between closely related species. Four strains were studied: *Bacillus anthracis* Sterne strain (animal vaccine), *Bacillus thuringiensis* (insecticide), *Bacillus cereus* (soil organisms) and *Bacillus globigii* (biowarfare simulant). The spores were separated from nutrient agar, suspended in deionized water, and immobilized on a graphite substrate. Atomic force microscopy was done in intermittent contact mode, in air, under reduced humidity. Height images showed that the spores had an irregular topography of subtle grooves, bumps, and steps across their upper surface. Phase images showed a superficial grain structure. Although some similarities were observed among spores of the same species, there was also significant variability within each species. The four species were not distinguished by observed surface morphology. Surface texture analysis (roughness, power spectral density, and bearing) did not establish quantitative differences between species. Overall, atomic force microscopy revealed a spore surface morphology rich with information. Additionally, it appears, that further analysis and a larger sample size could provide sufficient information to allow identification and differentiation between *B. anthracis* and its close relatives.



AFIT's Atomic Force Microscope

Anthrax Spore



The **AFIT Commandant's Award** is presented to the graduating student, or team of students, who produce the most exceptional master's thesis. The 2002 Award of the Commandant's Award for the Graduate School of Engineering and Management's most exceptional master's thesis honor went to Captain Zolock. The Air Force Research Laboratory sponsored the thesis. Captain Zolock's thesis advisor was Dr. Charles A. Bleckmann from the Department of Systems and Engineering Management, Graduate School of Engineering and Management.

AFIT Graduates – Keep in touch with your friends through the Association of Graduates (AOG). Membership in the AFIT AOG is open to graduates, current and former faculty, and, as associate members, students and friends of the Air Force Institute of Technology. Did you know that the AOG has the latest alumni information on their website?

http://www.afit-aog.org

EXPERIMENTAL VANGUARD - SPACE BASED LASER FLUID FLOW CHARACTERISTICS

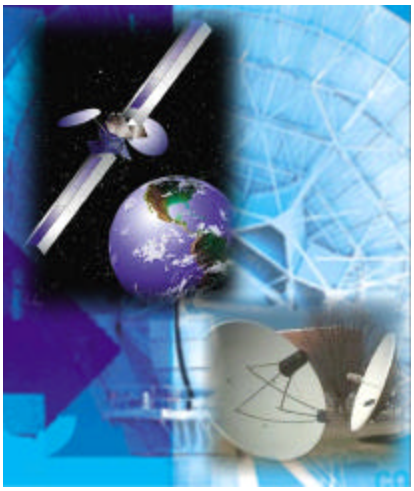
The Space Based Laser (SBL) program consists of the launch of a constellation of satellites into orbit around the earth to provide a national missile defense shield. A number of the SBL program areas are under development. The U.S. Air Force has contracted to develop and deploy a technology demonstrator for the Program. The technology demonstrator is called the SBL Integrated Flight Experiment (SBL IFX). The SBL IFX will prove the technology necessary for a network of satellites to utilize multi-megawatt power, cylindrical, gas dynamic lasers to destroy ballistic missiles in their boost phase of flight. The fluid dynamics internal to the high power laser is the focus of the research. Contractors had performed two-dimensional computational analysis of the fluid flow within the portion of the IFX that generates the laser necessary to kill a target. The first experimentation that has been performed specifically for the SBL IFX was conducted at AFIT.

The objectives of the experimental research were to build a facility that could simulate the expected fluid flow properties in the conceptual SBL IFX gas dynamic laser using cold-flow, and to investigate the performance of the model. A scale model of one quadrant of the SBL IFX cylindrical, gas dynamic laser was fabricated and mated to a blow-down/vacuum combination wind tunnel. By performing future, low-cost experimental tests using cold-flow and the subscale model used for this research (with modifications), the general performance of the contractor design may be assessed. By determining the fluid flow characteristics within the subscale, experimental model, parallels can be drawn to the full size SBL IFX. This will help determine if the next stage of testing should proceed, which involves a multi-million dollar test facility at Stennis Space Center, National Aeronautics and Space Administration. This facility would test a full size model of the SBL IFX using hot flow (a laser beam will be generated).

Captain Scott E. Bergen thesis titled, "Fabrication and Cold-Flow Testing of Subscale Space Based Laser Geometry," reported the results of the experiments. The thesis was the recognized as the 2002 Best Fluid Mechanics Thesis in the Department of Aeronautics and Astronautics, Graduate School of Engineering and Management, Air Force Institute of Technology and a presentation was conducted at the May, 2002, AIAA Plasma Conference.

WHAT? WEATHER IN SPACE?

Space weather storms impair high frequency and satellite communications, degrade GPS navigation accuracies, accelerate the decay of satellite orbits, electrically charge and damage geosynchronous satellites, and pose radiation hazards to astronauts. The United States Air Force is the sole provider of space weather support to warfighters throughout DoD. To improve this support, AFIT is working with a host of organizations—including Space Command and the Air Force Research Laboratory—to help develop next-generation space weather computer models, as well as adapt the power of existing science to ensure uninterrupted operational capabilities. Recent research conducted at AFIT involves the reliability and characteristics of space weather data collected continuously by the Defense Meteorological Satellite Program (DMSP). Such data is critical for maximizing the accuracy of space weather forecasting. Capt Herbert L. Keyser explored plasma densities measured by DMSP in his thesis "Validation and Characterization of Ionospheric Densities Measured by DMSP," while Capt Bradford S. Green studied DMSP plasma temperatures in his thesis "Validation and Assessment of DMSP Electron Temperatures in the Topside Ionosphere." Major Devin J. Della-Rose was the AFIT faculty advisor for both projects.

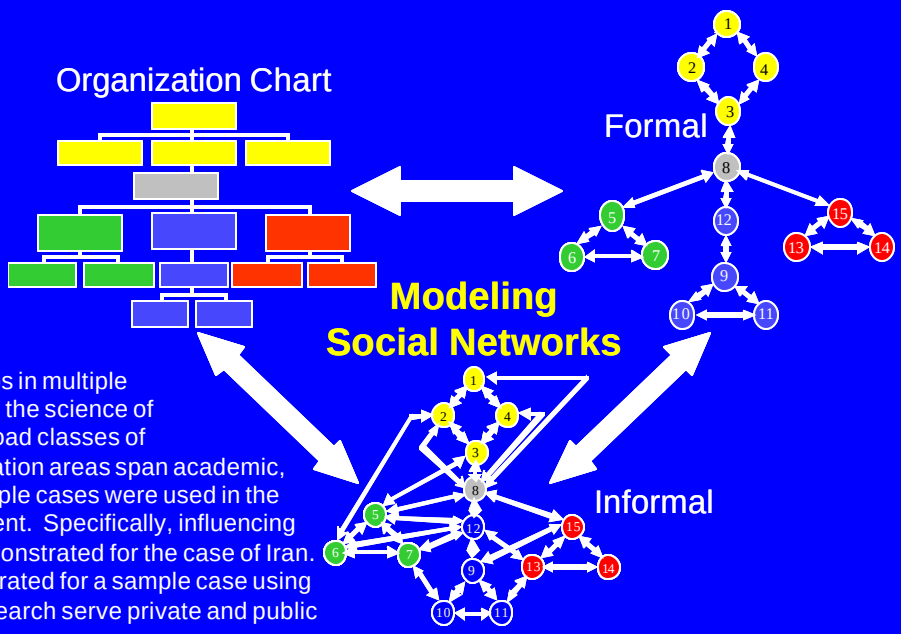


Letters To The Editor: What is a U-A-V?

We had some inquiries from the field in regards to our use of UAV in the January 2002 Issue of *Research News*. We had indicated in our article that UAV referred to "Uninhabited Air Vehicles," as that was the abbreviation in the research paper. The comments from the field referred to UAV as "Unmanned Aerial Vehicle" and referenced the OSD roadmap - http://www.acq.osd.mil/usd/uav_roadmap.pdf (We, especially, appreciate the helpful comments by Lt Col William A. Malec of the USAF Unmanned Aerial Vehicle Battlelab on this subject.)

We encourage feedback on *AFIT Research News.* Please contact **AFIT.enrsta@afit.edu** if you have some ideas to share on the topics presented in our publication.

New Methods for Modeling and Analysis of Social Networks



Recent doctoral research at AFIT develops new methods for the modeling and analysis of social networks. Social networks describe the complex relationships of individuals and groups in multiple overlapping contexts. This research advances the science of Operations Research and its application to broad classes of problems dealing with social networks. Application areas span academic, private sector, and government analysis. Sample cases were used in the research from the private sector and government. Specifically, influencing foreign government decision making was demonstrated for the case of Iran. Counter- terrorism applications were demonstrated for a sample case using Usama Bin Ladin. The contributions of the research serve private and public sector users.

The research formally defines and proves the mathematical properties of social closeness as a measure of influence between individuals and organizations. Social network analysis was mapped to a classic operations research flow model allowing for more detailed results with fewer mathematical assumptions than existing social network analysis techniques. This approach was extended to goal programming model of multiple, possibly competing, objectives. Aggregation/disaggregation techniques were developed which allow for the analysis of individuals and organizations within the same model. Aggregation and efficient solution techniques increase tractability of problems previously thought impractical or impossible to solve. Psychological profile-based approaches were developed. Psychological profile methods were found to be most appropriate for low data, high cardinality, non-cooperative scenarios (for example, political, business, or military adversaries). Overall this research developed better tools for the analysis of social networks.

Social network analysis impacts all government decision-making processes that rely on or model human behavior. Specifically, the research relates to financial and business decision-making (for example, acquisition, personnel manning requirements), granting security clearances, modeling and predicting foreign government actions, leadership, and military decisions, modeling transnational organizations (for example, terrorist networks), and psychological operations.

Captain Robert S. Renfro II dissertation, *"Modeling and Analysis of Social Networks,"* is the foundation of this research. The AFIT faculty advisor of this research was Professor Richard F. Deckro of the Department of Operational Sciences. This research project was sponsored by the National Security Agency and the National Air Intelligence Agency.

Faculty Focus: *Editor - Military Operations Research*

Dr. Richard F. Deckro is a Professor of Operations Research in the Department of Operational Sciences in the Graduate School of Engineering and Management. He holds a Bachelor of Science in Industrial Engineering from the State University of New York at Buffalo, a Masters of Business Administration and a Doctorate of Business Administration in Decision Sciences from Kent State University. Dr. Deckro was recently named as the Editor of *Military Operations Research*.

Dr. Deckro's research and consulting interests are in the areas of information operations, campaign modeling, applied mathematical programming and optimization, project management, scheduling, network models, and multi-criteria decision making. He is the current Chair of Working Group 8 – Information Operations/Information Warfare for the Military Operations Research Society (MORS). He is the Area Editor for Services for *Computers & Industrial Engineering* and serves on the editorial boards of *Computers & Operations Research* and *IEEE Transactions on Engineering Management* . He is also the current Secretary/Treasurer of the Military Applications Society of INFORMS. Dr. Deckro recently chaired the MORS' workshop entitled *Operations Research Methods for Information Operations: A Battlespace of the 21st Century* held in April of 2002. It was Dr. Deckro's pleasure to serve as dissertation advisor to Capt Robert Renfro's research work, *Modeling and Analysis of Social Networks*.

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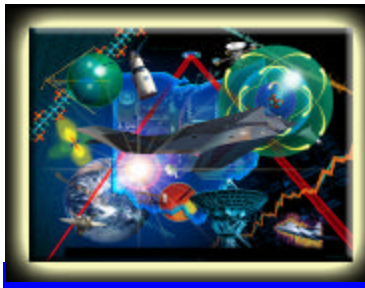

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RESEARCH NEWS

Basic research at the Air Force Institute of Technology is an important activity which leads to technological progress and the highest quality education. Research is an essential ingredient of academic life because it creates the questioning and creative background characteristic of graduate-level teaching and learning. AFIT's research focuses on support of the United States Air Force and the Department of Defense. AFIT students perform exciting research that has future applications in ensuring the technological supremacy of our nations defenses.

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